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1

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TITLE DESIGN OF A TRANSURANIC VUV SPECTROMETER

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DESIGN OF A TRANSURANIC VUV SPECTROMETER

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The physics of 5f materials includes such interesting solid state phenomena[1] as itinerant and localized magnetism, heavy fermion superconductivity, strongly interacting Kondo systems, and similar phenomena that can be associated with narrow 5f bands. The radial extent of the 5f wave function in the light actinides is sufficient to form narrow 5f bands (in contrast to 4f systems), while in the heavy actinides the 5f levels are localized. An actinide contraction similar to that of the 4f series occurs in the latter.

The crossover point between localized and delocalized behavior in pure metals occurs somewhere around neptunium or plutnium. The many allotropic phases[2] in these metals suggest participation of the nearly localized 5f electorns in the bonding, which surely must be of very short range. Thus it is anticipated that the most interesting narrow band phenomena would occur in the transuraniuc materials Np and Pu and their compounds. In spite of the current emphasis on high-T_c superconductors there is likely to be a substantial interest in transuranic research in the future.

Most of our present knowledge about the physics of 5f systems derives from studies of uranium and its compounds. This is particularly true in the case of photoemission measurements where the intense radioactivity has prevented studies at synchrotron sources. The development of a transuranic VUV spectrometer capable of safe operation at a synchrotron source would represent a giant step in 5f research. We present below a conceptual design of such a spectrometer.

The major hazard of actinide materials is intense α-radioacitivity which is easily stopped by any structural material (even a layer of air). Actinides are harmful only if ingested. The whole safety concept of a transuranic system then is containment of samples in order to prevent ingestion of even minute quantities. Any transuranic apparatus of necessity consists of two parts. The first is mechanical and involves the various safety features which are designed to fail safe in case of an accident. The second, however, is a set of strict operating procedures which must be adhered to for safe operation in order to prevent accidents in the first place. Both are important. We first consider the hardware.

Figure 1 shows a schematic layout of a VUV spectrometer and sample preparation system capable of handling transuranics. The entire system is envisioned as a single portable unit which detaches from the beamline when not in use. The spectrometer chamber is kept as a clean system where both "hot" (radioactive) and "cold" (non-radioactive) samples can be measured. It is connected to the beamline via a small slit which serves the dual purpose of preventing migration of small particles up the beamline, and as a delay line (allowing time to close fast valves) in case of a catastrophic loss of vacuum. The "hot" sample preparation chamber is entirely enclosed in a glovebox where <u>all</u> surface preparation of "hot" samples is done. A series of right angle transfers are required to introduce the "hot" samples into the spectrometer chamber. This again serves a dual purpose. First the right angles prevent a direct line-of-sight into the spectrometer chamber, and second, the three transfers vastly improve the chances of keeping the spectrometer chamber contamination-free since each subsequent transfer line is "colder" than the previous transfer line. Only the sample itself and the sample holder are "hot" in the spectrometer.

Pre-cleaned "hot" samples are introduced into the preparation chamber through an interlock system, as shown in Fig. 1. They are brought to the synchrotron from the home lab in a sealed UHV container and transferred into the glovebox via a magnetically-coupled sample rod so that at no time are they exposed to the atmosphere. All roughing pump lines are exhausted through a series of filters to the roof. Key valves in the transfer lines are interlocked so that one cannot open to the beamline when the prep chamber is open to the spectrometer.

Other safety features not shown in the figure include: a) Fast-acting valves in the beamline that are interlocked to the spectrometer vacuum; b) Radiation monitoring devices strategically located in the spectrometer and in the beamline; c) Safety covers on all optical ports; d) Inert atmosphere at a slight under-pressure in the glovebox; e) External dry active waste disposal container for all suspect materials; f) External radiation counters; f) Water cooling of glovebox to dissipate heat during bakeout of sample prep chamber; g) Ultrasonic vibrator in prep chamber to remove loose dust from scraped samples prior to transferring. While the system described above should be able to withstand safely a catastrophic vacuum failure; it is nonetheless essential to have a set of Strict Mandatory Operation Procedures as an integral part of any transuranic system. A complete operating manual should be developed. It should contain, at a minimum, the basic procedures outlined here: 1) The entire system must be limited to sub-gram quantities of material so that even in a "worst case scenario" we are dealing only with minute quantities of material; 2) Samples are brought to the ring just prior to measurement and removed immediately upon completion of experiment; i.e., no long-term storage of samples; 3) Samples are stored in a double containment mode, except in the sepctrometer chamber during actual measurement when a qualified operator is present; 4) System is confined to stable materials only - single crystals when possible. This exclues gas-phase work; 5) All surface preparation is done in the glovebox-enclosed sample preparation chamber; 6) Samples are pre-cleaned in the home lab; 7) Strict inventory of all materials is to be maintained; 8) Frequent (possibly daily) external and internal radiation monitoring to detect problems before they develop; 9) Monthly check of exhaust filters; 10) Cleaning of spectrometer chamber in the home lab whenever background α-radiation exceeds $\approx 10^4$ dpm (most likely once a year).

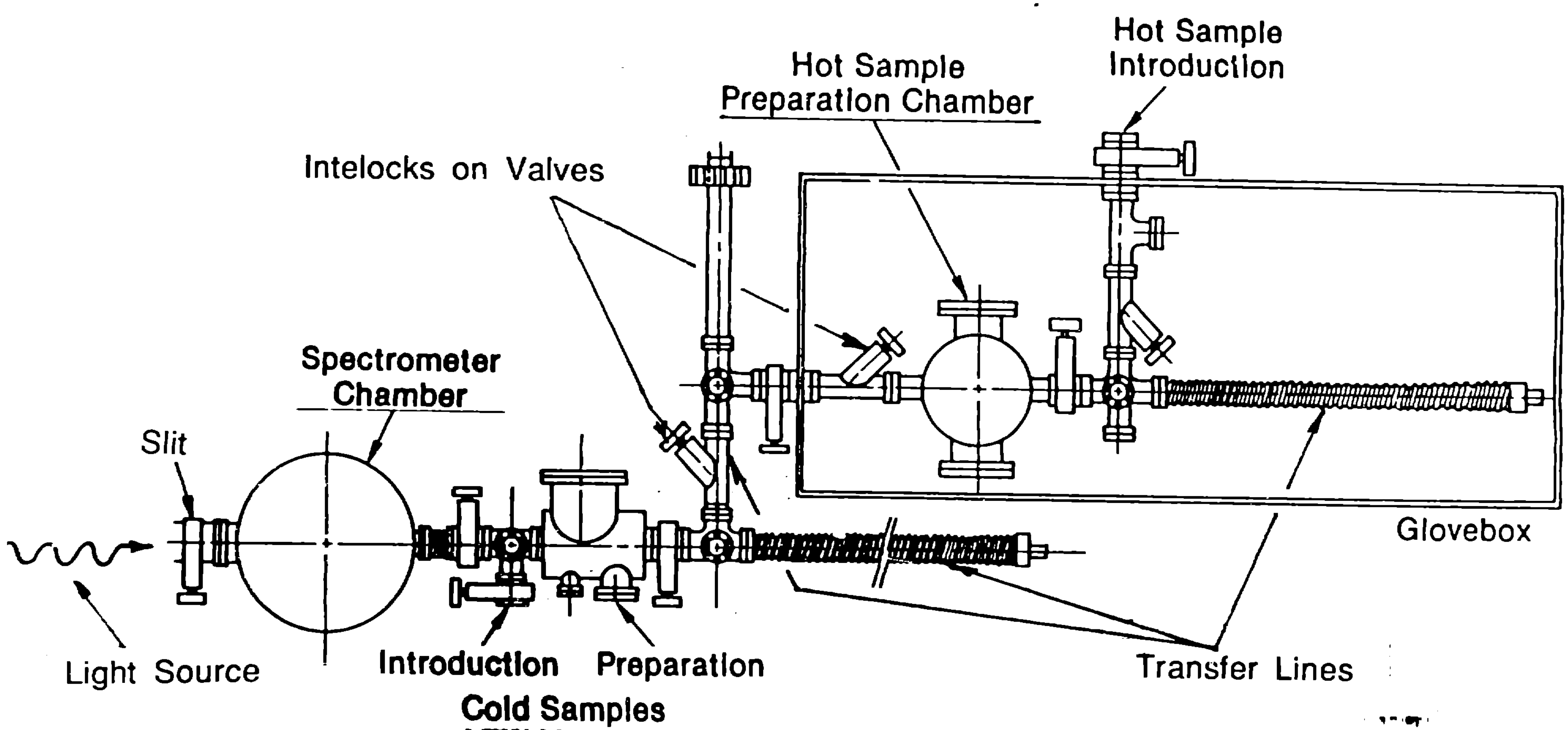
Similar systems have operated successfully at Los Alamos and at Karlsruhe.[3] Substantial contamination was accumulated in the Karlsruhe experimental chamber because of the single transfer rod which served the dual purpose of transfer rod and sample manipulator. Our multiple transfer system overcomes the problems encountered there. Indeed, with the implementation of all the precautions noted above, there is no reason why safe operation at a synchrotron source would not be possible.

References

1. See for example "The Handbook on the Physics and Chemistry of the Actinides," A. J. Freeman and G. H. Lander eds (North Holland, Amsterdam).
2. J. L. Smith, Z. Fisk, and S. S. Hecker, in Proceedings of the Conference on Electronic Structure and Properties of Rare Earth and Actinide Intermetallics, St. Polten, Austria, 1984, pp. 151-158.
3. J. R. Naegele, J. Ghijsen and L. Manes, in Structure and Bonding 59/60 (Springer-Verlag, Berlin, Heidelberg) 1985, pp. 198-262.

Figure Captions

Fig. 1 Schematic layout of a transuranic VUV spectrometer, emphasizing the essential features of such a system.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Introduction
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Introduction
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